

STUDENT NUMBER

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Letter

BIOLOGY

Written examination

Friday 30 October 2015

Reading time: 9.00 am to 9.15 am (15 minutes)

Writing time: 9.15 am to 11.45 am (2 hours 30 minutes)

QUESTION AND ANSWER BOOK

Structure of book

<i>Section</i>	<i>Number of questions</i>	<i>Number of questions to be answered</i>	<i>Number of marks</i>
A	40	40	40
B	11	11	70
			Total 110

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners and rulers.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.
- No calculator is allowed in this examination.

Materials supplied

- Question and answer book of 45 pages.
- Answer sheet for multiple-choice questions.

Instructions

- Write your **student number** in the space provided above on this page.
- Check that your **name** and **student number** as printed on your answer sheet for multiple-choice questions are correct, **and** sign your name in the space provided to verify this.
- All written responses must be in English.

At the end of the examination

- Place the answer sheet for multiple-choice questions inside the front cover of this book.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

SECTION A – Multiple-choice questions**Instructions for Section A**

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** for the question.

A correct answer scores 1, an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

Question 1

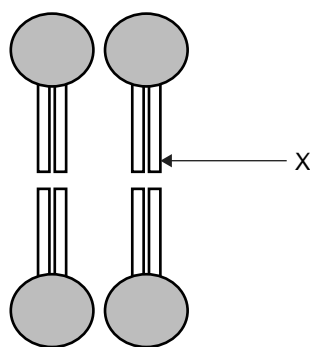
Starch, cellulose and glycogen are examples of polysaccharides found in living cells.

All three polysaccharides

- A. contain carbon, hydrogen, oxygen and nitrogen.
- B. are broken down by condensation reactions.
- C. are formed by joining monomers of glucose.
- D. are synthesised using an input of water.

Question 2

The diagram below represents the arrangement of a type of molecule found in the plasma membrane of a cell.

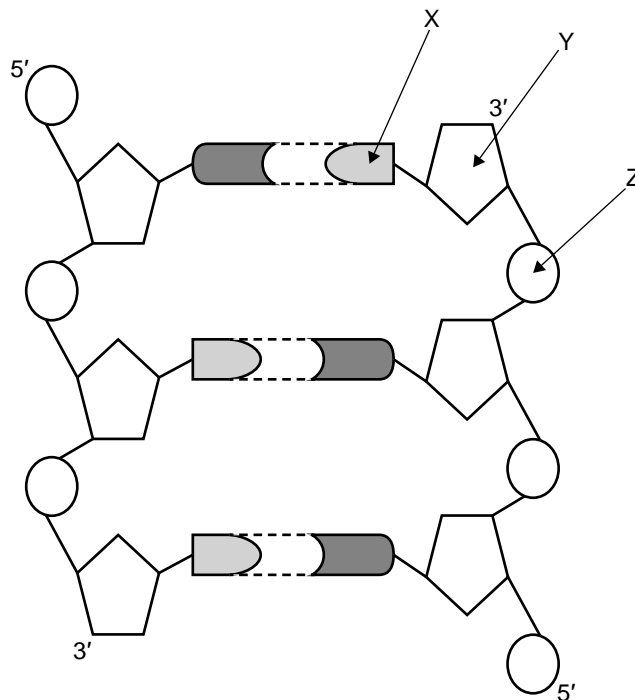


The structure labelled X in the molecule is

- A. a protein.
- B. a fatty acid.
- C. a disaccharide.
- D. an amino group.

Use the following information to answer Questions 3 and 4.

The diagram below represents part of a DNA molecule.



Question 3

A single DNA nucleotide is shown by sub-unit(s)

- A. X alone.
- B. X and Y together.
- C. Y and Z together.
- D. X, Y and Z together.

Question 4

A feature of DNA that can be seen in the diagram above is

- A. the anti-parallel arrangement of the two strands of nucleotides.
- B. the process of semi-conservative replication.
- C. its ribose sugar-phosphate backbone.
- D. its double-helix structure.

Question 5

All specialised cells that secrete protein molecules

- A. have a rigid cell wall.
- B. contain numerous lysosomes.
- C. contain functional chloroplasts.
- D. have an extensive Golgi apparatus.

Question 6

An experiment was conducted to investigate enzyme activity. A small quantity of amylase solution was added to a solution of starch dissolved in water at 35 °C. It was observed that maltose was produced.

Which one of the following is the substrate in this reaction?

- A. water
- B. starch
- C. maltose
- D. amylase

Question 7

The production of adenosine triphosphate (ATP) is represented by the following equation.

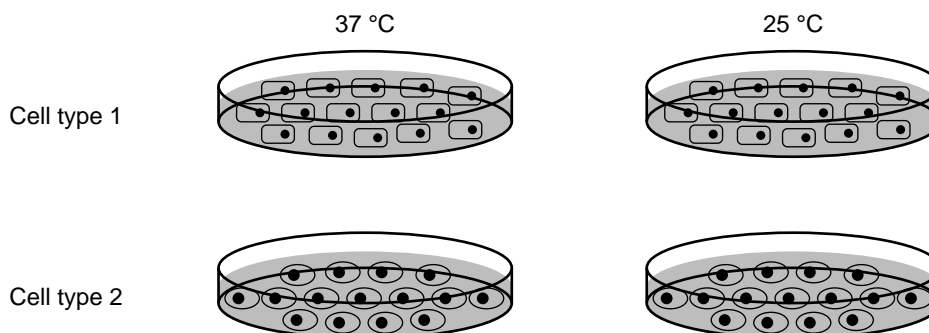


The production of ATP

- A. is a catabolic reaction.
- B. requires an overall input of energy.
- C. only occurs in the absence of oxygen.
- D. occurs only in the mitochondria of a cell.

Question 8

In an investigation into the uptake of a protein by cells, scientists immersed two cell types in solutions of this protein. The investigation was carried out at two different temperatures and the percentage of the protein taken up by the two cell types was recorded over 10 minutes.



The data was presented in a table, as shown below.

Time (mins)	Cell type 1 Percentage of protein taken up by cell		Cell type 2 Percentage of protein taken up by cell	
	At 25 °C	At 37 °C	At 25 °C	At 37 °C
0	0	0	0	0
2	2	5	5	10
4	4	10	10	20
6	6	12	12	24
8	8	16	16	32
10	8	16	18	36

Which one of the following conclusions is supported by the data?

- A. The rate of uptake of this protein at 25 °C is not affected by cell type.
- B. The percentage of this protein taken up by Cell type 1 is not affected by temperature.
- C. The rate of uptake of this protein by Cell type 2 is faster at 37 °C than at 25 °C.
- D. If the experiment continued for another 10 minutes, the percentage of this protein taken up by Cell type 1 would increase.

Use the following information to answer Questions 9 and 10.

Rotenone is a chemical compound that is used as an insecticide and a piscicide (a substance that kills fish). The rotenone molecule disrupts the electron transport chain in animal cells by interfering with one of the essential reactions within the electron transport chain.

Question 9

Which one of the following statements best explains the effect of rotenone in causing death in insects and fish?

- A. The rate of glycolysis would increase.
- B. ATP would accumulate in the mitochondria.
- C. Aerobic respiration in the mitochondria would be disrupted.
- D. The cell membrane would no longer be permeable to oxygen.

Question 10

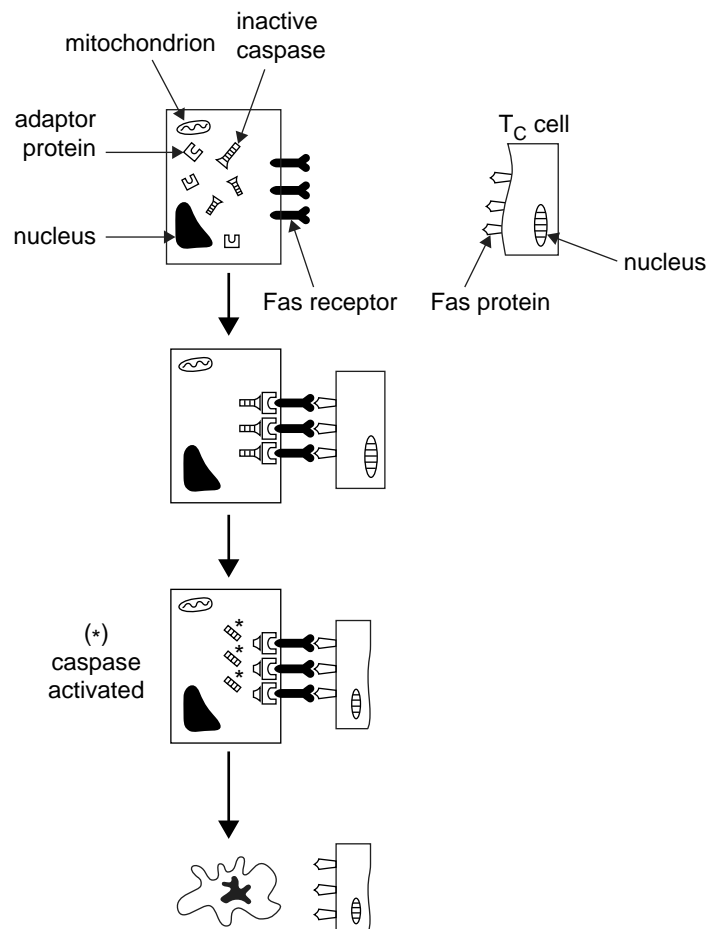
In the past, people sometimes put extracts containing rotenone into a river to poison the fish, allowing the fish to be more easily caught. When rotenone-poisoned fish are eaten by people, no poisonous effect is observed.

Which one of the following statements best explains this observation?

- A. Rotenone is not absorbed through the cell membranes of people who have eaten poisoned fish.
- B. Rotenone is not absorbed by fish tissue and remains dissolved in water.
- C. Human cell metabolism does not involve the electron transport chain.
- D. Rotenone only affects organisms that respire anaerobically.

Question 11

Regulated cell death occurs in ageing and damaged cells. This process involves activated enzymes called caspases. Caspase activation leads to the breakdown of the cytoskeleton, the mitochondrial membrane and the nuclear membrane. To become activated, caspases must be cut at a specific amino acid sequence. One pathway for caspase activation is initiated by a cytotoxic T cell (T_C), as shown in the diagram below.



This diagram shows that the

- cell death pathway is initiated by DNA damage.
- caspases and adaptor proteins compete for sites to bind to the Fas receptor.
- breakdown of the mitochondrial membrane activates a range of caspase enzymes.
- attachment of the Fas protein to the Fas receptor is required for caspase activation.

Question 12

A student was investigating four cell types from different organisms. She recorded the results of her microscopic examination of the cells in the table below.

	Cell W	Cell X	Cell Y	Cell Z
Mitochondria	few	many	absent	few
Chloroplasts	present	absent	absent	present
Nucleus	present	present	absent	present

Which one of the following is the correct conclusion that can be drawn from this data?

- A. Cell W could be a muscle cell from an insect.
- B. Cell Y could be a living leaf cell from a corn plant.
- C. Cell X could be a heart-muscle cell from a mammal.
- D. Cell Z could be an underground root cell from a pea plant.

Question 13

Which one of the following is true of chemical signalling molecules?

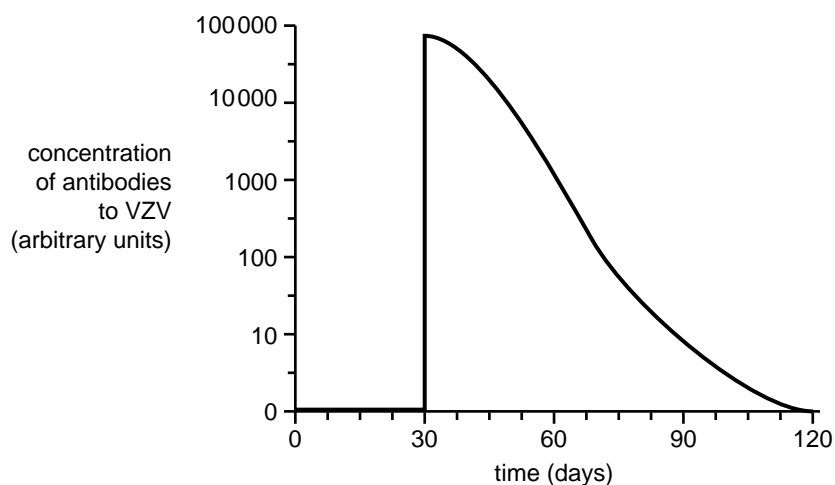
- A. They always produce a rapid response.
- B. They produce a response in target cells when released.
- C. They only stimulate an effect on the cell that produced them.
- D. They require carrier proteins to be transported through body fluids.

Question 14

Chickenpox (varicella) is a highly contagious viral disease caused by the varicella-zoster virus (VZV).

A technician measured the concentration of antibodies to VZV in a person's blood over a 120-day period. An event occurred on day 30 that significantly altered the concentration of antibodies.

The concentration of antibodies over the 120 days is displayed in the graph below.



Which one of the following events could have occurred on day 30?

- A. an exposure of the person to VZV
- B. a booster vaccination against VZV for the person
- C. an injection of antibodies to VZV into the person
- D. an oral dose of antibiotics was given to the person

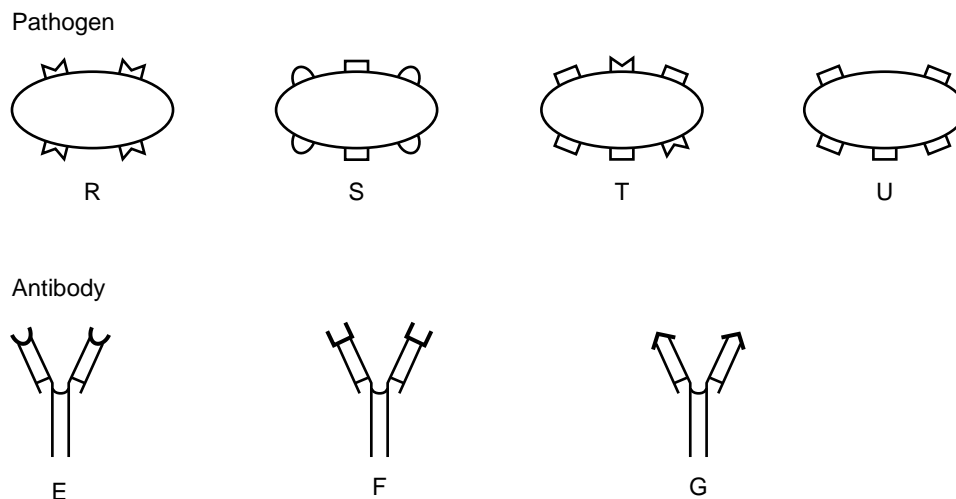
Question 15

Which one of the following is true of prions?

- A. They have an outer wall made of cellulose.
- B. They cause some brain diseases.
- C. They contain nucleic acids.
- D. They are unicellular.

Question 16

Consider the following diagram of four pathogens and three antibodies.



Which one of the following statements is correct?

- A. Antibody E would be effective against both pathogen S and pathogen R.
- B. Antibody F is effective against three of the pathogens.
- C. There are no antibodies effective against pathogen U.
- D. Antibody G is only effective against pathogen R.

Question 17

Which one of the following is an example of a plant defence against a pathogen?

- A. production of antibodies
- B. an active immune system
- C. extensive cell death throughout the plant
- D. waxy leaf surfaces acting as physical barriers

Question 18

A girl is carrying a piece of wood. A small piece breaks off and becomes embedded in her finger. The next day, she notices an inflammatory response occurring in her finger.

In the region around the small piece of wood embedded in her finger

- A. mast cells would release antibodies.
- B. the skin tissue would become pale and cold.
- C. the capillaries would become more permeable.
- D. red blood cells would leave the blood vessels and engulf foreign material.

Question 19

Autoimmune diseases are different from diseases caused by pathogens because in all autoimmune diseases

- A. certain self-tissues are not recognised as ‘self’ and this causes an immune response to the tissues.
- B. histamine is released from mast cells to cause an inflammatory response.
- C. complement protein causes the breakdown of healthy cells.
- D. interferon is released to kill infected tissue.

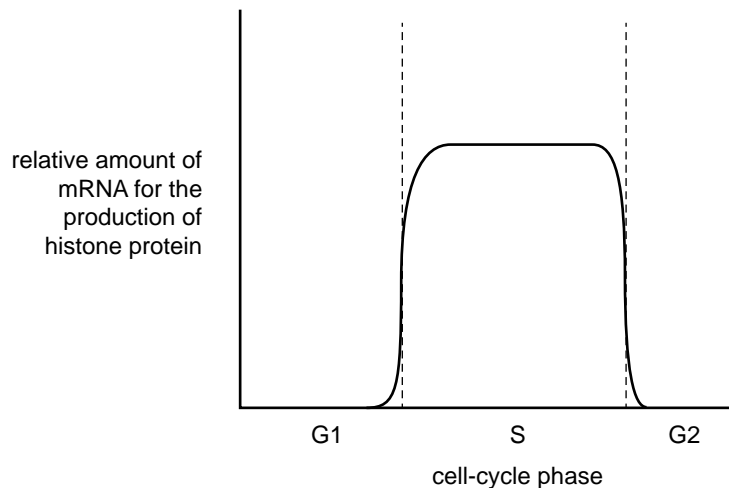
Question 20

Which one of the following is true of prokaryotic cell division?

- A. There is an equal division of the cytoplasm.
- B. Daughter cells of varied genetic composition are formed.
- C. Replicated chromosomes consist of two sister chromatids joined by a centromere.
- D. Membrane-bound organelles are randomly distributed between the daughter cells.

Question 21

The graph below shows the relative amount of mRNA for the production of histone protein at different times throughout a cell cycle.

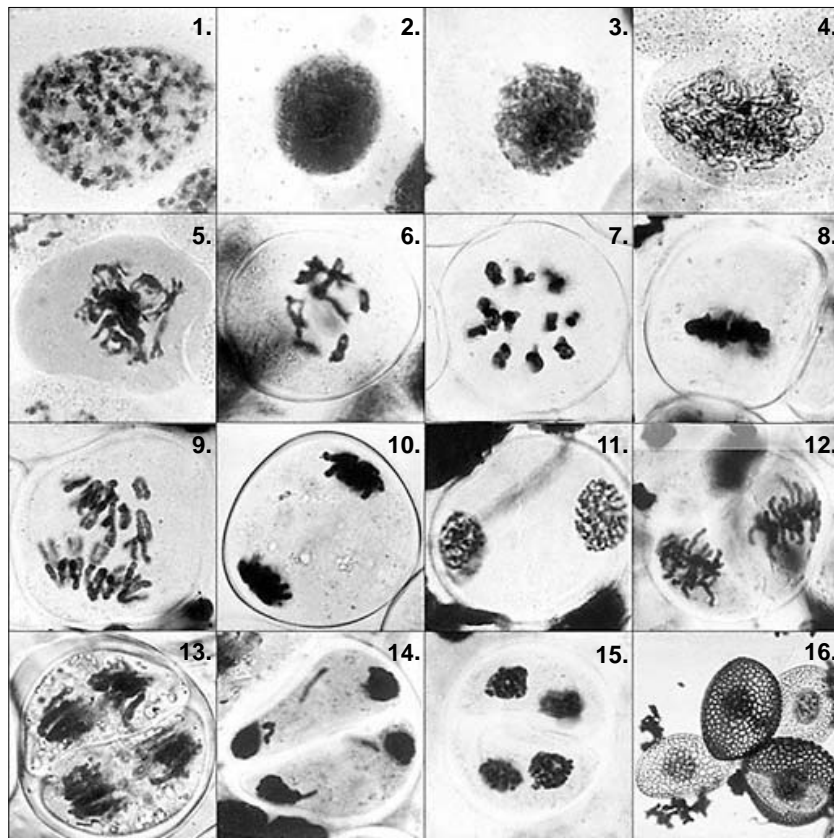


Using your knowledge of the cell cycle and the information in the graph, it is correct to state that

- A. DNA replication occurs most actively in the G1 phase.
- B. histone genes are highly active throughout the cell cycle.
- C. histone protein synthesis occurs simultaneously with DNA synthesis.
- D. histone protein is not present in the cell during the G1 and G2 phases.

Question 22

The following images show stages in meiosis in the order in which they occur.



Source: Radboud University Nijmegen, Faculty of Science,
www.vcbio.science.ru.nl (Virtual Classroom Biology)

Which one of the following statements is correct?

- A. During the stage shown in image 9, chromatids separate.
- B. Cells after the stage shown in image 10 are haploid.
- C. During the stage shown in image 11, DNA will be replicated.
- D. Homologous chromosomes pair up in the stage shown in image 12.

Question 23

The following is a sequence of amino acids located within a polypeptide: – Asn – Gly – Pro – Arg – Ser –

1st position (5' end) ↓	2nd position				3rd position (3' end) ↓
	U	C	A	G	
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	STOP	STOP	A
	Leu	Ser	STOP	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

Using the table provided, the DNA template sequence that could code for this amino acid sequence is

- A. TTG / CCC / GGT / GCT / TCG
- B. TTG / GTT / GGT / GCT / TCG
- C. TTG / CCC / GGT / GCT / TCT
- D. UUG / CCC / GGU / CGU / UGC

Question 24

The genome of the northern white-cheeked gibbon, *Nomascus leucogenys*, has been sequenced and compared to other primate species.

The *N. leucogenys* genome would

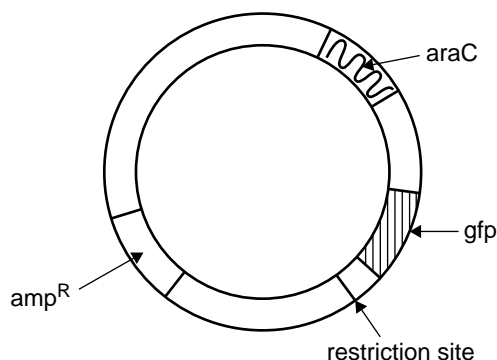
- A. include only the non-coding DNA sequences.
- B. be an uninterrupted, circular sequence of DNA base pairs.
- C. be identical to the genome of the black-crested gibbon, *Nomascus concolor*.
- D. consist of all the genetic sequences within the haploid cells of individuals of the species.

Use the following information to answer Questions 25–27.

To clone a gene of interest, the following four steps are performed:

1. A plasmid is cut with a specific restriction enzyme.
2. The gene of interest is ligated into the plasmid.
3. Plasmids are transferred to bacteria.
4. Bacteria are grown on four nutrient agar plates (labelled W, X, Y and Z) that are coated with or without ampicillin and arabinose.

An example of a plasmid used in cloning is shown below.



This plasmid contains a restriction site and the following three genes:

- amp^R – confers resistance to the antibacterial agent ampicillin
- gfp – encodes the green fluorescent protein (GFP), which fluoresces under UV light
- $araC$ – encodes a protein required to promote the expression of gfp when arabinose is present

The results from a bacterial transformation experiment are shown in the table below.

Plate	W untransformed bacteria only	X untransformed bacteria only	Y transformed bacteria	Z transformed bacteria
Diagram of plate				
Added to plate	nutrient agar only	nutrient agar and ampicillin	nutrient agar, ampicillin and arabinose	nutrient agar and ampicillin
Description of result	lawn of bacteria	no growth	bacterial colonies present	bacterial colonies present

Question 25

Bacteria are used in gene cloning because they

- A. contain restriction enzymes that randomly cut chromosomes into fragments of varying size.
- B. can replicate non-bacterial sequences of DNA in a short time.
- C. replicate exponentially by undergoing mitotic divisions.
- D. allow the entry of foreign DNA into their nuclei.

Question 26

Which plate would contain bacteria that fluoresce under UV light?

- A. plate W
- B. plate X
- C. plate Y
- D. plate Z

Question 27

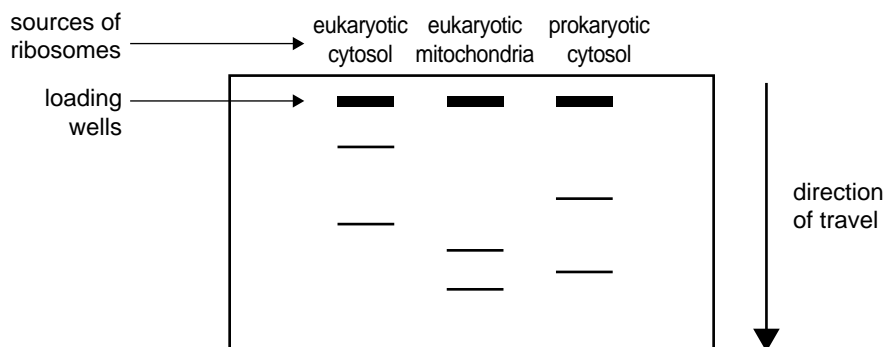
Which one of the following statements is an accurate description for the purpose of plate W or X?

- A. Plate W shows that the plasmid was cut with a restriction enzyme.
- B. Plate W shows that the percentage of transformed bacteria was high.
- C. Plate X shows that the nutrient agar promoted the growth of viable bacteria.
- D. Plate X shows that ampicillin was effective in killing the untransformed bacteria.

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Question 28

A ribosome contains two distinct sub-units: a large sub-unit and a small sub-unit. Ribosomes from prokaryotic and eukaryotic cells were isolated and subjected to gel electrophoresis. The results are shown below.



Which one of the following can be correctly concluded from the gel electrophoresis results?

- A. Eukaryote cytosolic and mitochondrial ribosomes translate the same types of protein.
- B. Eukaryote mitochondria contain the ribosomal sub-units of the smallest size.
- C. Prokaryote ribosomal sub-units have opposing charges to each other.
- D. Eukaryote cytosolic ribosomal sub-units travel at the greatest speeds.

Question 29

Source: Alexandr III/Shutterstock.com

Human fingerprints are formed in the first three weeks of embryonic development. No two individuals have identical ridge patterns in their fingerprints.

It is reasonable to suggest that the enormous variety observed in human fingerprints is due mainly to

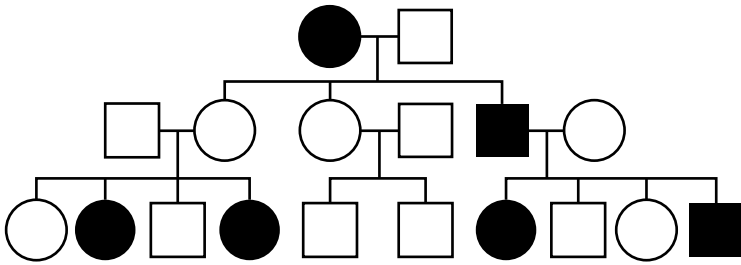
- A. the accumulated effects of polygenes.
- B. environmental factors experienced after birth.
- C. the combination of alleles present at one gene locus.
- D. the expression of genes located on the X-chromosome.

Question 30

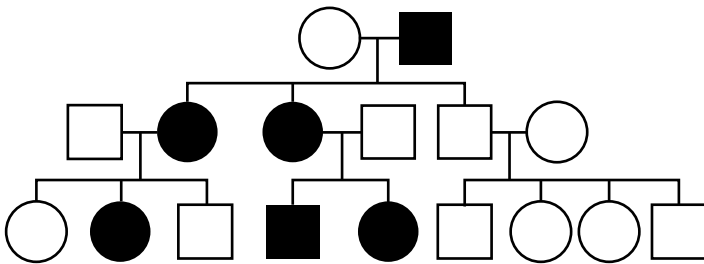
Kearns-Sayre syndrome is a rare genetic trait caused by a deletion of up to 10 000 nucleotides from the mitochondrial DNA (mtDNA). Most individuals with this syndrome have weak eye muscles, drooping eyelids, vision loss and, often, short stature.

The pedigree that shows a family affected by a mitochondrial trait such as Kearns-Sayre syndrome is

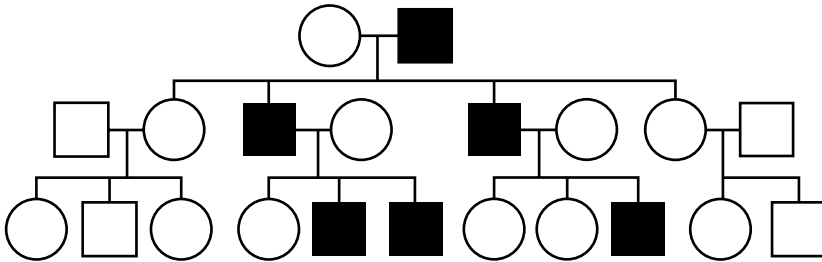
A.



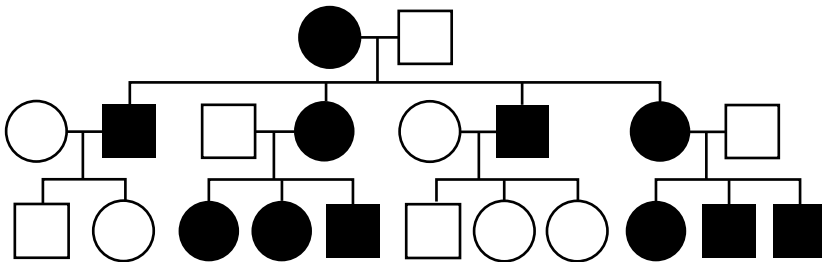
B.



C.

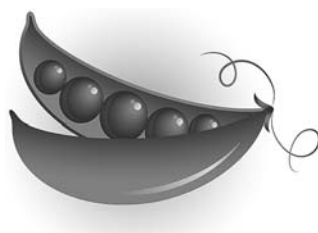


D.



Use the following information to answer Questions 31–33.

In garden pea plants, *Pisum sativum*, the shape of the pods can be inflated or constricted, while the colour of the pods can be yellow or green.



inflated pod



constricted pod

Source (both): jara3000/Shutterstock.com

Experiment 1: Pea plants homozygous for inflated pods were crossed with pea plants homozygous for constricted pods. The offspring were then crossed among themselves.

Experiment 2: Pea plants homozygous for yellow pods were crossed with pea plants homozygous for green pods. The offspring were then crossed among themselves.

The resulting phenotypic data for the F_2 generations from each experiment are shown below.

Experiment 1		Experiment 2	
Shape of pod	Number of offspring in F_2	Colour of pod	Number of offspring in F_2
inflated	882	yellow	152
constricted	299	green	428
Total	1181	Total	580

Question 31

Based on the data, it can be stated that in garden peas

- A. further crosses are required to determine the nature of pod colour inheritance.
- B. inflated pod shape is dominant to constricted pod shape.
- C. pod colour and shape are co-dominant characteristics.
- D. green pod colour is recessive to yellow pod colour.

Question 32

Inflated pod plants from the F_1 generation were crossed with their constricted pod parents to produce a total of 280 offspring.

The expected numbers of offspring with each phenotype are

- A. 280 inflated : 0 constricted
- B. 210 inflated : 70 constricted
- C. 70 inflated : 210 constricted
- D. 140 inflated : 140 constricted

Question 33

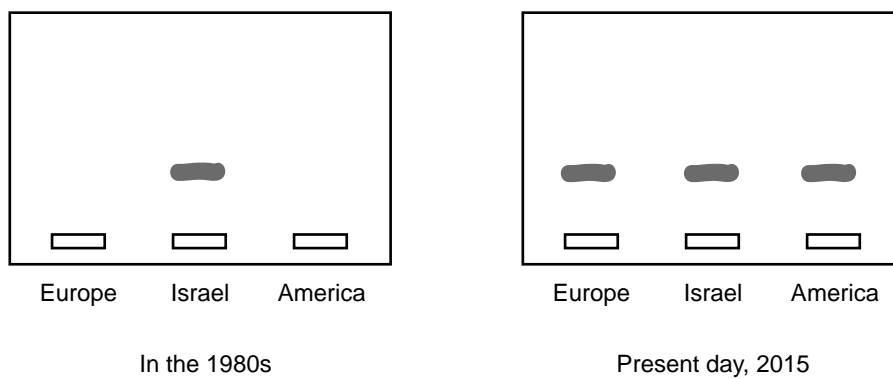
The genes for pod shape and colour assort independently. A cross was performed between two plants that are heterozygous for both pod shape and colour.

The ratio of phenotypes observed in the offspring, with respect to pod shape and colour, would be

- A. 3 inflated, yellow : 1 constricted, green
- B. 9 inflated, green : 3 constricted, yellow : 3 inflated, yellow : 1 constricted, green
- C. 9 inflated, green : 3 constricted, green : 3 inflated, yellow : 1 constricted, yellow
- D. 1 inflated, green : 1 constricted, yellow : 1 inflated, yellow : 1 constricted, green

Question 34

The wheat leaf blotch pathogen (*Mycosphaerella graminicola*) is present in many parts of the world. The spores of the pathogen can be carried on the wind and on exported wheat. The diagrams below show gels of the shared restriction fragment length polymorphism (RFLP) allele at a particular RFLP locus in *M. graminicola* populations from three locations.



With respect to *M. graminicola*, this present-day result is evidence of

- A. gene flow between populations.
- B. genetic drift in isolated populations.
- C. random mutations within populations.
- D. asexual reproduction of this pathogen.

Question 35

Potassium-40 has a half-life of 1.25 billion years. In igneous rocks closely associated with a fossil layer, the ratio of potassium-40 to its radioactive breakdown product, argon-40, is approximately 1:1.

The age of the fossils in the fossil layer will be close to

- A. 125 million years.
- B. 310 million years.
- C. 1.25 billion years.
- D. 2.5 billion years.

Question 36

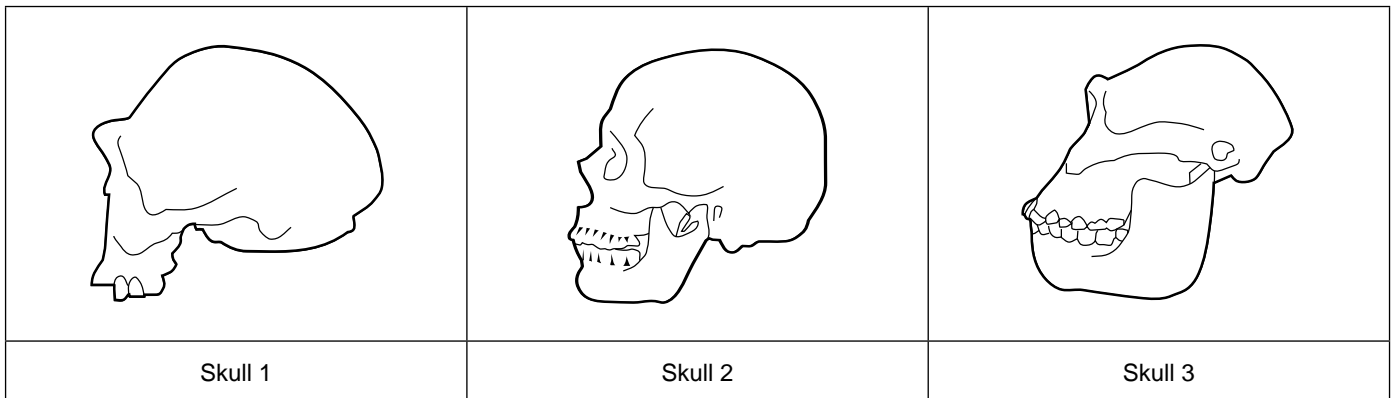
Biologists have found evidence for mass extinction events in Earth's history at approximately 65 million years ago (mya) and at approximately 200 mya. The fossil record indicates a rapid increase in diversity of species after these mass extinction events.

This increased diversity of species can be explained by

- A. decreased mutation rates associated with the extinction event.
- B. increased numbers of fossils produced by the extinction event.
- C. populations of species returning to their pre-extinction event size.
- D. the extinction of many species providing many unoccupied niches.

Question 37

Below are three images of fossil hominin skulls.



Which sequence best shows the order from the most ancient fossil skull to the most modern fossil skull?

- A. Skull 3, Skull 1, Skull 2
- B. Skull 1, Skull 2, Skull 3
- C. Skull 3, Skull 2, Skull 1
- D. Skull 1, Skull 3, Skull 2

Question 38

Fossil remains of a number of individuals from the genus *Australopithecus* were found at various sites in the eastern half of Africa and have been dated to between 3–4 million years old.

These fossil remains

- A. are descendants of *Homo erectus*.
- B. represent the oldest evidence found of primates.
- C. show early evidence that hominins were bipedal.
- D. represent the earliest examples of the hominoid super-family.

Question 39

Advances in DNA technology have made it possible to carry out genetic screening for particular genetic diseases. Some people may decide not to have children based on the result of their genetic screening.

This decision will

- A. alter the frequency of an allele and will, therefore, have an impact on future human evolution.
- B. have no impact on future human evolution since the genes or DNA are not altered in the testing.
- C. increase genetic variation in the human population and will, therefore, have an impact on future human evolution.
- D. result in complete loss of an allele from a population and will, therefore, have an impact on future human evolution.

Question 40

Northern elephant seals, *Mirounga angustirostris*, were nearly hunted to extinction in the 1890s, with only about 20 individuals left at the end of the century. The population has now grown to more than 120 000. In the 1890s, southern elephant seals, *Mirounga leonina*, were not as severely hunted and currently there are estimated to be 600 000 southern elephant seals.

Based on this information, it is true to say that

- A. northern elephant seals have evolved as a result of the 'founder effect'.
- B. northern elephant seals would show less genetic variation than southern elephant seals.
- C. southern elephant seals would have experienced greater genetic drift than northern elephant seals.
- D. the mutation rate in northern elephant seals would have been greater than in southern elephant seals.

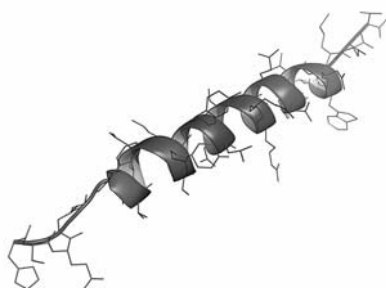
SECTION B – Short-answer questions**Instructions for Section B**

Answer **all** questions in the spaces provided. Write using black or blue pen.

Question 1 (8 marks)

The diagrams below represent examples of three levels of structure with respect to the folding and assembly of a protein. The diagrams are not to scale.

A.



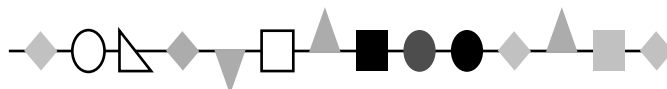
alpha-helix

B.



human interferon

C.



a polypeptide sequence

Sources: molekuel.be/Shutterstock.com (A.); petarg/Shutterstock.com (B.)

- a. i. Complete the table below to indicate the diagram that represents the structural level of the protein given. 1 mark

Structural level of protein	Diagram (A., B. or C.)
primary	
secondary	
tertiary	

- ii. Name the molecular sub-unit of a protein. 1 mark

The particular shape achieved by the folding of a protein is of great significance. Proteins sometimes fold incorrectly to form groups of joined, identical polypeptide sequences called aggregates. Sufferers of Alzheimer's disease have aggregates of various sizes in their brain tissue. Aggregates of amyloid beta protein are present in their brain tissue. These patients experience memory loss and have large areas of dead neurons in their brains.

Several hypotheses have been suggested as possible explanations for neuron death. One hypothesis is summarised below.

Hypothesis: Aggregates of amyloid beta protein could cause death of neurons.

Explanation: These aggregates have star-like shapes that pierce the plasma membrane.

- b. Suggest, by referring to cellular function, how aggregates of amyloid beta proteins could result in death of neurons.

2 marks

- c. In healthy brain tissue, other proteins, called molecular chaperones, bind temporarily to a protein during its folding process to allow the correct folding and assembly of the protein. Researchers are trying rational drug design to mimic the action of molecular chaperones as a treatment for Alzheimer's disease.

Describe **one** structural characteristic of the molecular chaperone proteins that would need to be considered in order for this approach to provide a successful treatment.

1 mark

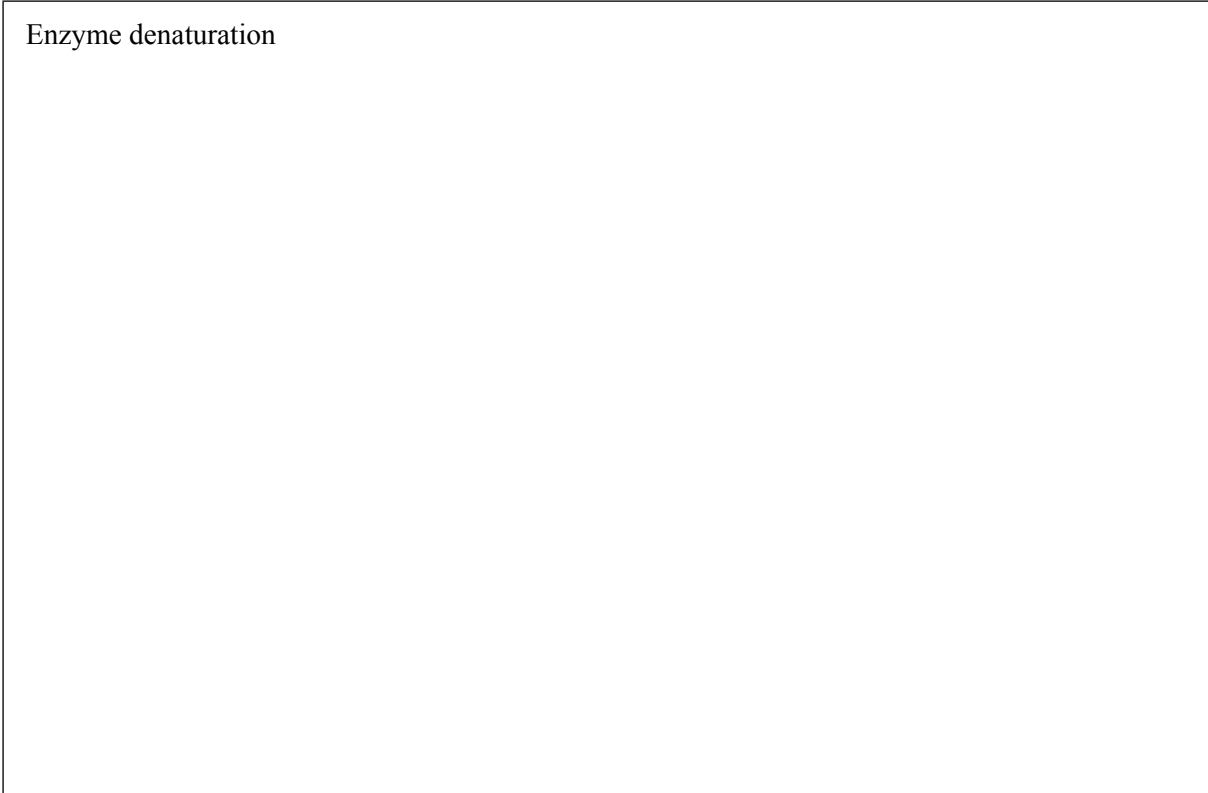
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- d.** Enzymes are protein catalysts.

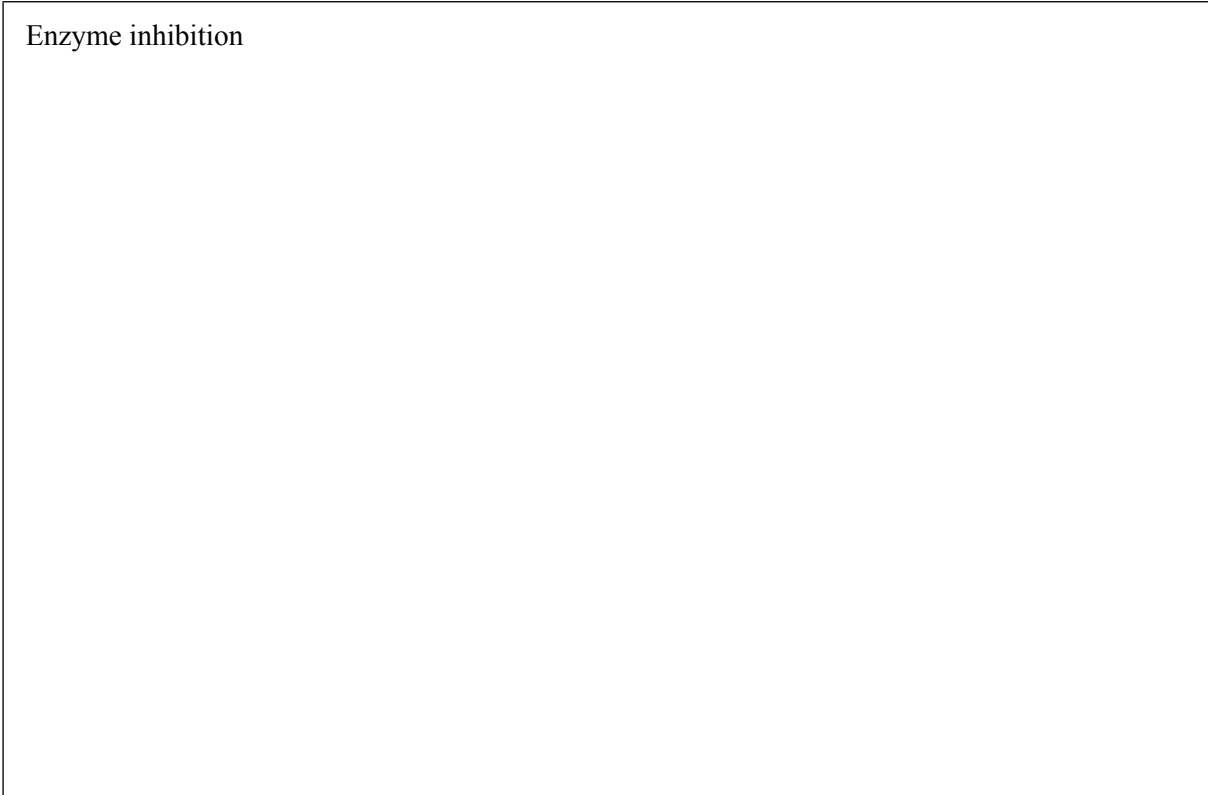
Use labelled diagrams to illustrate both enzyme denaturation and enzyme inhibition. Include both the enzyme and substrate in your diagrams.

3 marks

Enzyme denaturation



Enzyme inhibition



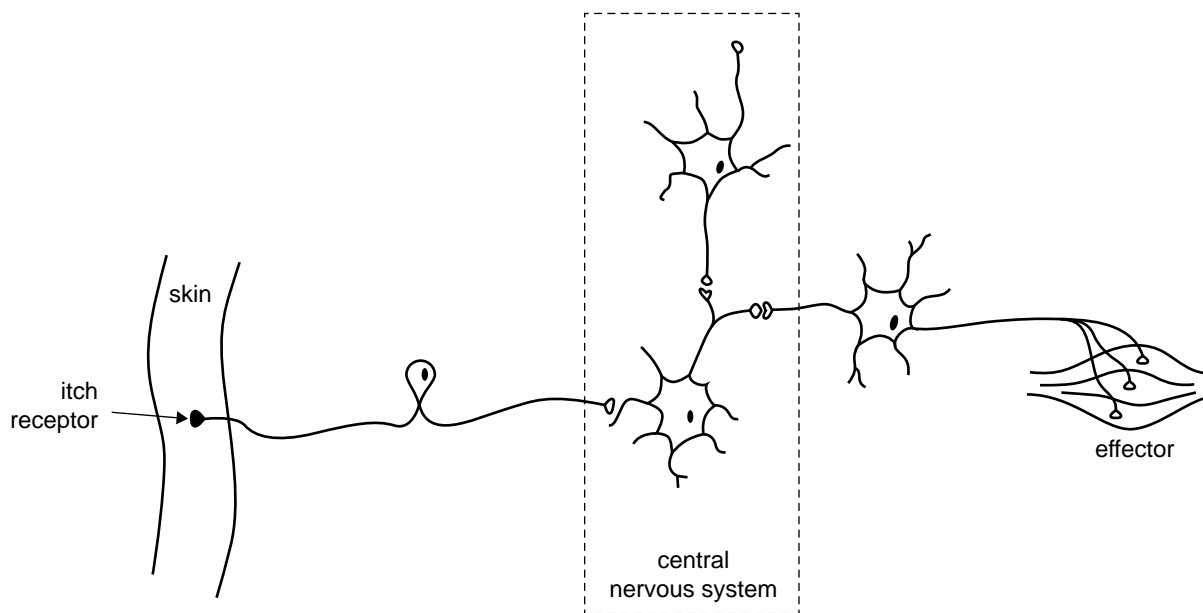
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SECTION B – continued
TURN OVER

Question 2 (8 marks)

The following diagram shows cells involved in detecting and responding to itch stimuli. An example of an itch stimulus is the bite of an insect, which can result in itchy skin. The response to an itch is scratching.



a. i. Using an arrow, indicate on the diagram above the position of one synapse. 1 mark

ii. Describe how a signal is transferred across the synapse. 3 marks

- b. Scientists are currently studying the molecular mechanisms that cause itchy skin. It has been discovered that many different receptors and signalling molecules are involved. Two specific itch receptors (H1 and TLR7) have been identified and their cellular locations are shown in the table below.

Complete the table by suggesting the chemical nature of the signalling molecule that is specific for each receptor. Justify your answers.

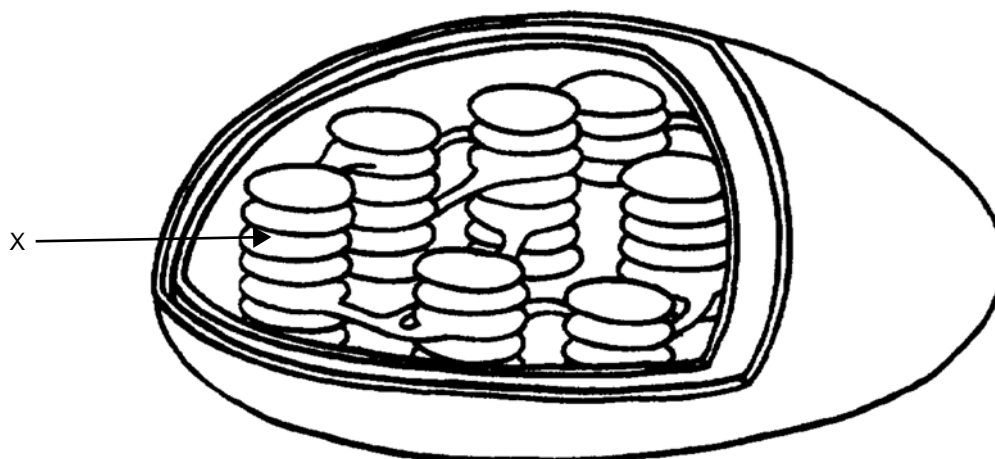
4 marks

Name of itch receptor	Receptor location	Chemical nature of signalling molecule	Justification
H1	plasma membrane		
TLR7	inside the cell		

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Question 3 (4 marks)

Below is a diagram of a chloroplast.



Source: J Soucie; © BIODIDAC

- a. Name the structure labelled X. 1 mark
-
- b. Complete the following table by referring to the diagram above and your knowledge of photosynthesis. 3 marks

Name of the stage of photosynthesis that occurs at X	_____	
Two input molecules that are required for reactions at X	1. _____	2. _____
Two output molecules that result from the reactions at X	1. _____	2. _____

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Question 4 (6 marks)

In 2014, an outbreak of Ebola virus disease (EVD) occurred in West Africa. Humans may contract the virus from infected animals or from an infected person.

In 2014, there was no safe and effective vaccine available to prevent EVD.

- a. Explain how an effective vaccine could provide long-term immunity to EVD. 4 marks

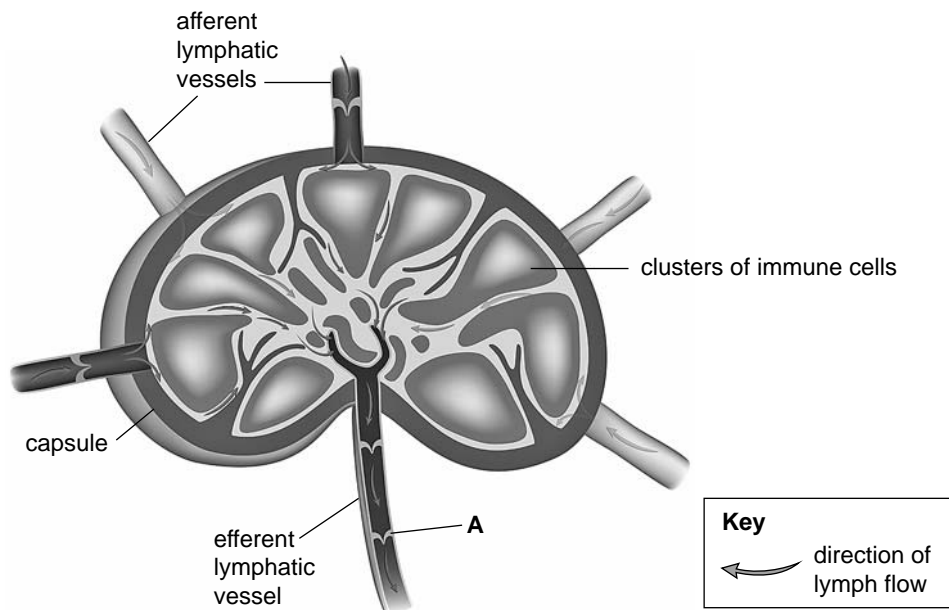
- b. Scientists developing new vaccines for EVD are conducting trials in animal subjects. To evaluate the effectiveness of a new vaccine, both humoral and cell-mediated responses are measured in the animal subjects.

Explain how these two immune responses are different. Give **two** differences in your answer. 2 marks

Question 5 (5 marks)

Consider the following diagram of a lymph node.

Anatomy of a lymph node



Source: Alila Medical Media/Shutterstock.com

- a.** Describe the role of the structure labelled A, found within the efferent lymphatic vessel. 1 mark

Immune cells are clustered within the lymph node (see diagram). There is more than one type of immune cell within each of these clusters.

- b.** Name and describe the role of **one** type of immune cell found within these clusters that plays a role in the innate immune response. 2 marks

- c. Another of the immune cell types found within these clusters has a large nucleus and extensive rough endoplasmic reticulum, and plays an important role in an adaptive immune response.

Name this cell type and explain how the extensive rough endoplasmic reticulum assists this cell to perform its function.

2 marks

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SECTION B – continued
TURN OVER

Question 6 (5 marks)

The diagrams below show a pair of homologous chromosomes during cell division.

Figure 1 shows the whole chromosomes and Figure 2 is an enlarged view of the section circled in Figure 1.

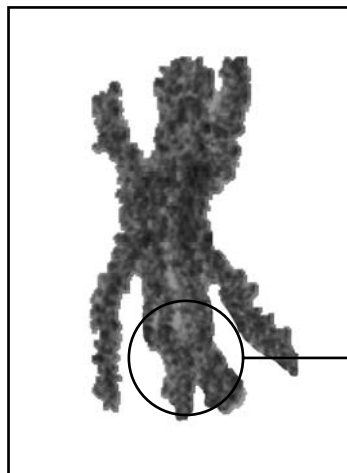


Figure 1

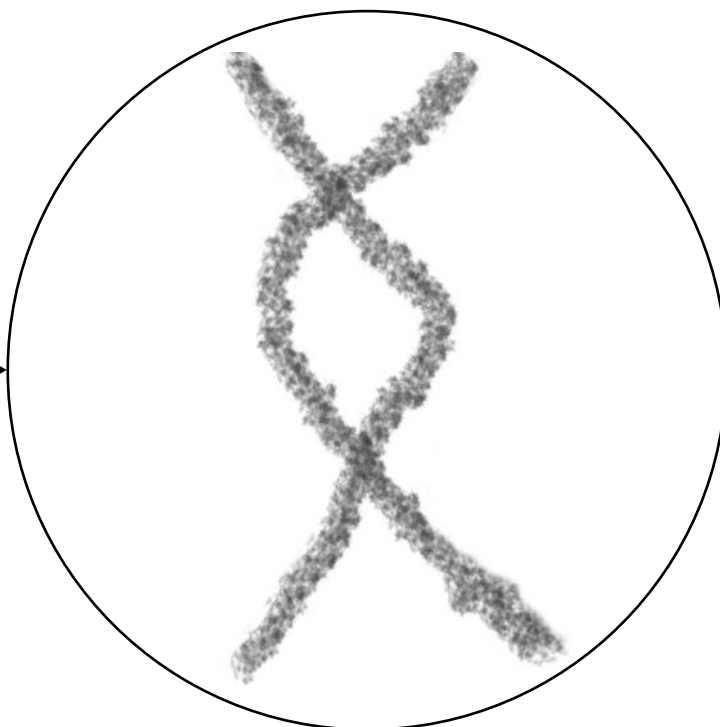


Figure 2

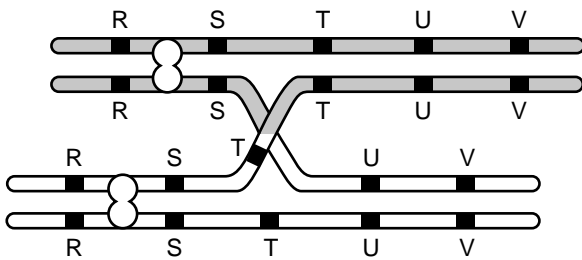
- a. Name the type of cell division that would be occurring for this arrangement of chromosomes to be observed.

1 mark

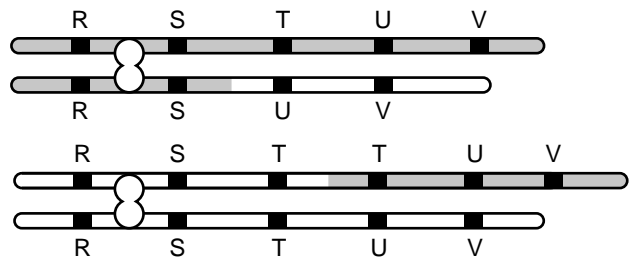
- b. i. What name is given to the process occurring in the circled area in Figure 1? 1 mark

- ii. What is the outcome of the process you named in **part b.i.** and what advantage does the result of this process give a species? 2 marks

- c. Sometimes mistakes occur in the process named in **part b.i.** One such mistake is shown in the diagrams below.



Process named in part b.i.



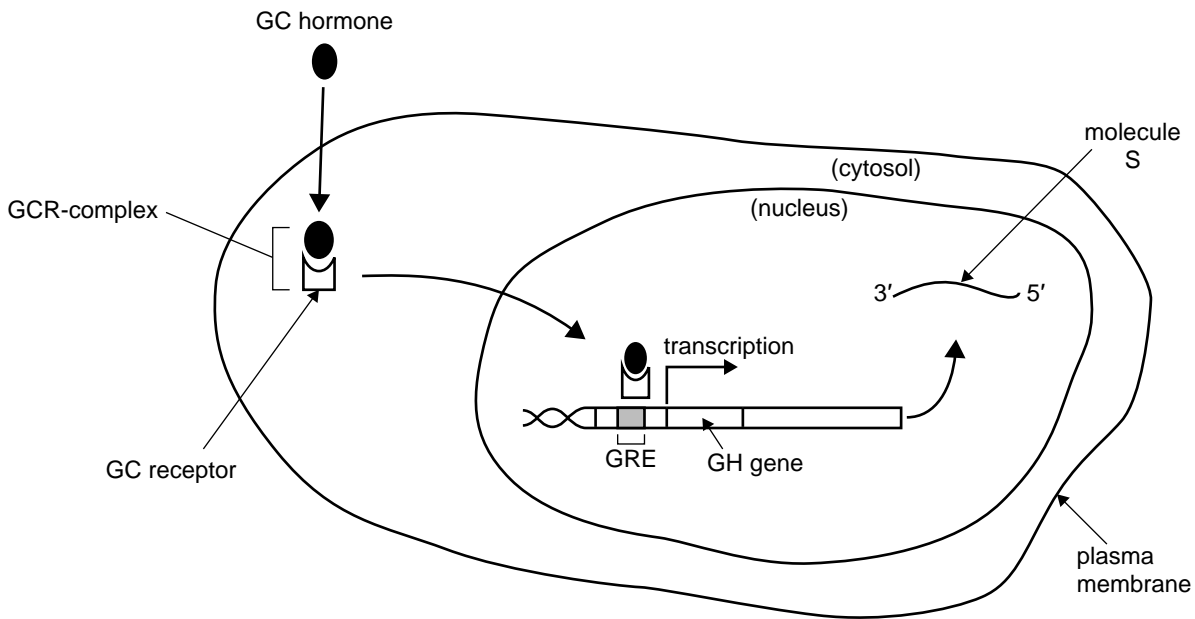
Result of process named in part b.i.

What will be the result of this mistake for the genetic makeup of the daughter cells? 1 mark

Question 7 (7 marks)

Glucocorticoid (GC) is a hormone in rats that binds to a receptor, as shown in the diagram below. The glucocorticoid-receptor complex (GCR-complex) moves into the nucleus and attaches to the DNA, causing transcription to begin.

GC signal transduction in rat pituitary gland cells



The location where the GCR-complex attaches to the DNA is called the glucocorticoid response element (GRE). The GRE is located approximately 250 base-pairs upstream of the growth hormone (GH) gene. Following the attachment of the GCR-complex to the GRE, an enzyme catalyses the transcription of the gene.

a. Name the enzyme that catalyses transcription. 1 mark

b. Name the transcription product, molecule S, and describe the processing that molecule S undergoes before it exits the nucleus. 3 marks

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- c. In the rat pituitary gland, GC stimulates the production of the growth hormone protein. However, in the rat liver, GC stimulates the production of the enzyme tryptophan oxygenase.

Given that the genetic sequence is identical in all somatic rat cells, explain how the production of distinct proteins in different cell types could occur.

2 marks

- d. If a human gene is inserted into the DNA of rat pituitary gland cells, these genetically engineered cells can be used to produce human growth hormone.

What characteristic of the genetic code enables a human protein, such as human growth hormone, to be made by rat cells?

1 mark

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Question 8 (8 marks)

Consider the template strand of a hypothetical gene, shown below. The exons are in bold type.

3' **TAC AAA** CCG GCC **TTT GCC AAA** CCC AAC CTA **AAT ATG AAA** ATT 5'

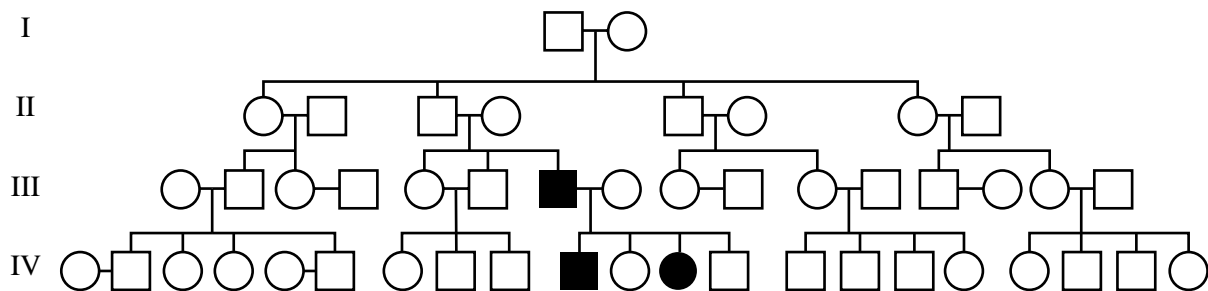
- Note: 1. The DNA triplet **TAC** indicates START and codes for the amino acid methionine that remains in the polypeptide.
 2. The DNA triplets **ATC**, **ATT** and **ACT** code for a STOP instruction.

- a. i. How many amino acids would be present in the polypeptide expressed by this gene? 1 mark

- ii. An allele for this gene codes for a polypeptide with only five amino acids. This is caused by a mutation in one of the exons. This mutation is a result of one nucleotide change.

By referring to the original sequence above, identify the nucleotide change that must have occurred to bring about this shorter polypeptide. 1 mark

- b. Hereditary retinoblastoma is a rare autosomal dominant trait. The pedigree below shows the trait appearing in a family with no prior history of the condition before generation III.



Explain the appearance of this trait in generations III and IV. 2 marks

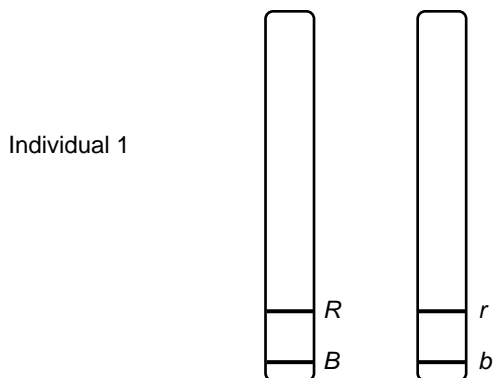
In the Australian sheep blowfly, *Lucilia cuprina*, eye colour can be red or white, and body bristles (stiff hairs) can be straight or crooked.



Lucilia (spp)

Source: William Ritchie/
Shutterstock.com

The diagram below represents a pair of homologous autosomes from a male blowfly with red eyes and straight bristles. The gene loci for eye colour (*R*) and bristle shape (*B*) are shown.



The genotype of this individual is written $\frac{BR}{br}$

- c. i. Complete the table below to show the genotypes of all four gametes formed in one meiotic division in this fly in both of the circumstances given in the table.

2 marks

Crossing-over event between <i>R</i> and <i>B</i> loci	Genotype of gametes			
	1	2	3	4
does not occur				
does occur				

A Biology student crossed a different, red-eyed, straight-bristled male with a white-eyed, crooked-bristled female. The phenotypes of the offspring produced were counted.

Phenotype of offspring	Numbers of offspring
red eyes, straight bristles	3
red eyes, crooked bristles	47
white eyes, straight bristles	47
white eyes, crooked bristles	3

- ii. Which one of the following three genotypes correctly represents the genotype of the male parent?

Circle your answer and justify your choice.

2 marks

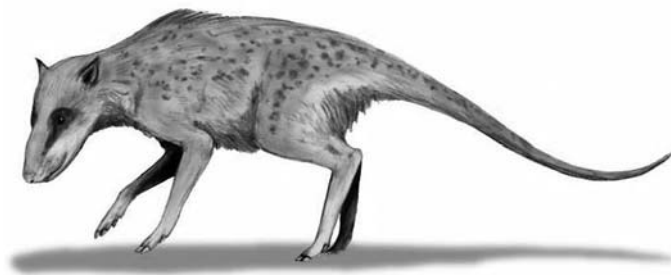
$$\frac{BR}{br}$$

$$\frac{Br}{bR}$$

$$\frac{BR}{BR}$$

Question 9 (6 marks)

A fossil of an extinct species called *Indohyus major*, found in northern India, is thought to share a recent common ancestor with the group of living organisms called cetaceans. Cetaceans include dolphins and whales.



Indohyus major

Source: Nobu Tamura (<http://spinops.blogspot.com>)

- a. Name the type of evolution that describes the relationship between *I. major* and cetaceans. 1 mark

For a long time, scientists have believed that cetaceans are related to the group of terrestrial mammals classified as artiodactyls, which includes pigs and hippopotami. The name artiodactyl refers to the shape of the feet or hooves of these animals.

To work out the evolutionary relationships between *I. major* and living animals, scientists closely studied their bones and skeletal structures.

- b. What name is given to the study of the similarities and differences between the bones and skeletal structures of animals, including fossils of extinct species? 1 mark

The table below shows a summary of the scientists' findings.

Animal	Feet	Limb bones	Inner-ear bones
cetaceans (e.g. whales)	artiodactyl	thick	thick
suids (e.g. pigs)	artiodactyl	thin	thin
hippopotamids (e.g. hippopotami)	artiodactyl	thick	thin
<i>I. major</i>	artiodactyl	thick	thick

c. i. Using all the information provided, complete the diagram below to show the evolutionary relationships between the following animals:

A. cetaceans (e.g. whales and dolphins)

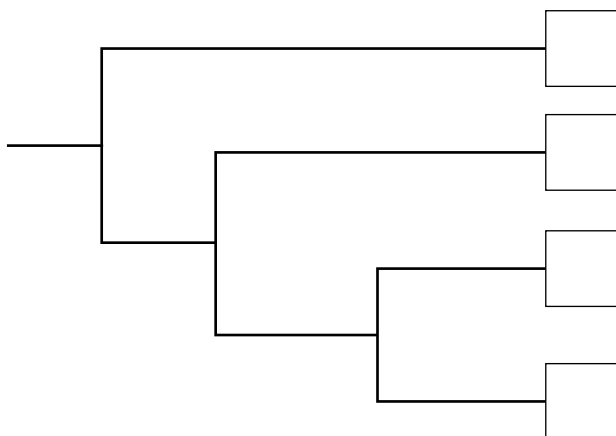
B. suids (e.g. pigs)

C. hippopotamids (e.g. hippopotami)

D. *I. major*

Write the corresponding letter of the animal (A.–D.) in the boxes provided.

2 marks

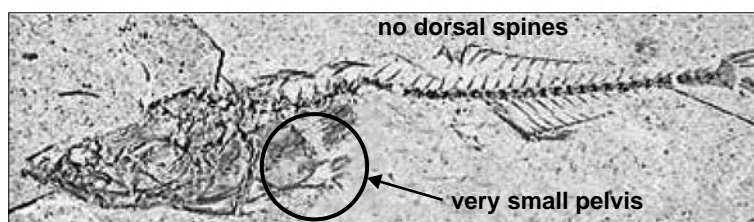
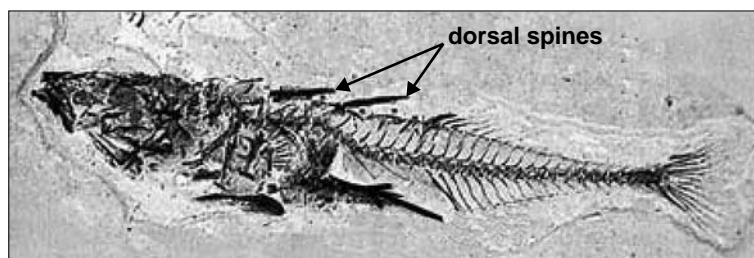


ii. Explain the reasoning behind your response to part c.i.

2 marks

Question 10 (5 marks)

Scientists studying the fossils in an ancient lake bed have an almost perfect fossil record ranging more than 25 000 years. In this fossil record, there are two forms of a fish called a 'stickleback'. One form has large spines on the back of the fish (dorsal spines) and large pelvic bones. The other form has smaller or no spines and smaller pelvic bones. Modern-day stickleback fish with large dorsal spines are common in the ocean, while the stickleback fish with small spines are more common in fresh water.



Sources (from top): AP Hendry, 'Darwin in the fossils', in *Nature*, vol. 451, 14 February 2008, p. 780 (reprinted with permission from Macmillan Publishers Ltd: *Nature*, © 2008, www.nature.com/nature/index.html); www.hhmi.org

The table below contains a summary of some structural features of the fossils found in different sediment layers in the ancient lake bed.

Sediment layer	Pelvis	Dorsal spines
top	small	small or absent
middle	large	large
lower	small	small or absent

- a. i. Suggest a hypothesis that could explain the change in the structural features seen in the different sediment layers.

1 mark

- ii. Give evidence from the information provided to support your hypothesis.

2 marks

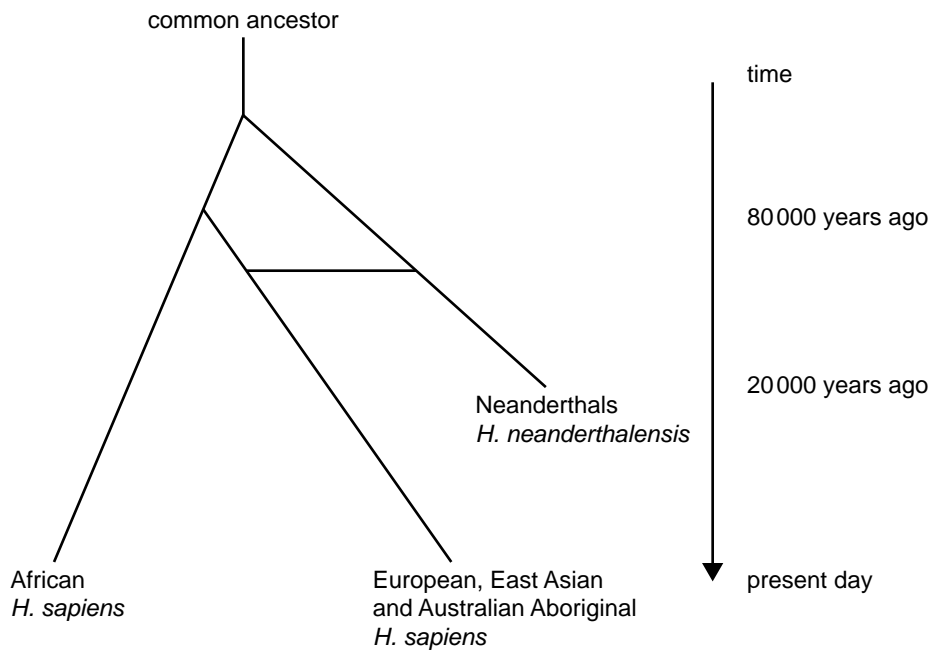
- b. Scientists studying modern-day sticklebacks taken from freshwater lakes have discovered that young fish that grow to have small pelvises and small or no dorsal spines grow more quickly and move faster as young fish than those that grow into fish that have larger pelvises and dorsal spines.

Outline how the sticklebacks with small pelvises have become more common over time in fresh water. 2 marks

Question 11 (8 marks)

Fossil evidence indicates that between 30 000–80 000 years ago, populations of the two hominin species – modern humans (*Homo sapiens*) and the extinct Neanderthals (*Homo neanderthalensis*) – lived close to one another in parts of the Middle East, Europe and Asia.

Researchers have constructed a theory about the relationships between ancient populations. This is represented in the following diagram.



Recent DNA evidence has shown that:

- the genome of living humans of African descent does not contain Neanderthal DNA
- the genomes of living humans of European, East Asian and Australian Aboriginal descent all contain small amounts of Neanderthal DNA (1–4%).

a. i. Suggest how DNA from *H. neanderthalensis* entered the genome of present-day European, East Asian and Australian Aboriginal *H. sapiens*, and continues to be found in modern populations. 2 marks

ii. What implication does this DNA evidence have for the classification of the two hominin species, *H. sapiens* and *H. neanderthalensis*, according to the common definition of a species? 1 mark

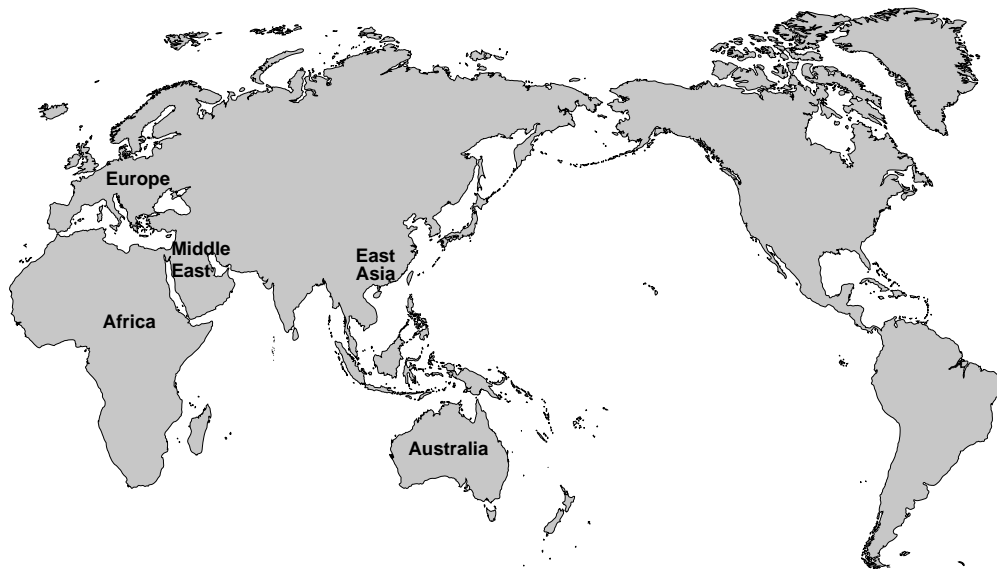
- b. There are several theories about the geographical origins of *H. sapiens*.

Scientists consider that the absence of Neanderthal DNA in present-day African *H. sapiens* lends support to one theory about the geographical origins of *H. sapiens*.

Name this theory and explain how the recent DNA evidence provided on page 44 supports it.

3 marks

- c. Consider the map provided below.



What does the DNA evidence provided on page 44 suggest about the route and timing of the migration of the first Australian Aboriginals to arrive in Australia?

2 marks

Route _____

Timing _____

END OF QUESTION AND ANSWER BOOK